

What is claimed is:

1           1.       A method of broadcasting a message in a wireless communication network  
2       having a plurality of communication units including a receiving communication unit having  
3       stored therein network topology information including information identifying neighboring  
4       communication units forming a first tier of neighbors and information identifying  
5       neighboring communication units of the first tier of neighbors forming a second tier of  
6       neighbors, the method comprising:

7               receiving the message at the receiving communication unit; and  
8               determining, based on the network topology information, whether to retransmit the  
9       message based on whether the neighbors of the receiving communication unit are also  
10       neighbors of another one of the plurality of communication units.

1           2.       The method of claim 1, wherein said determining whether to retransmit the  
2       message comprises determining not to retransmit the message if another communication unit  
3       among the plurality of communication units is configured to broadcast messages to a set of  
4       communication units that includes the first tier neighbors of the receiving communication  
5       unit and at least one other communication unit that is not a neighbor of the receiving  
6       communication unit.

1           3.       The method of claim 1, wherein said network topology information includes  
2       status information indicating whether the first tier communication units serve as one of a  
3       member, a cluster-head, and a gateway unit; and wherein the receiving communication unit  
4       determines that no communication unit identified within the network topology information is  
5       configured to transmit a message to a superset of communication units that includes the first  
6       tier neighbors of the receiving communication unit and at least one other communication unit  
7       that is not a neighbor of the receiving communication unit, the method further comprising:  
8               determining if the receiving communication unit is an articulation point; and  
9               retransmitting the message if the receiving communication unit is determined to be an  
10       articulation point.

1           4.     The method of claim 3, wherein the receiving communication unit is  
2 determined to be an articulation point if the first tier neighbors of the receiving  
3 communication unit cannot be divided into subsets such that the members of each subset are  
4 first tier neighbors to one of a cluster-head and a gateway communication unit.

1           5.     The method of claim 3, wherein  $N_k$  is a number of neighbor communications  
2 units to which the receiving communication unit is configured to transmit a message; and  
3 wherein said determining whether the receiving communication node is an articulation point  
4 comprises:

5           identifying for a neighbor of the receiving communication unit the number of  
6 communication units  $C_m$  to which the receiving communication unit and the neighbor  
7 communication unit can both transmit messages;

8           calculating for said neighbor of the receiving communication unit a percentage  
9  $P_q = C_m / N_k$  of the receiving communication unit's neighbors to which a neighbor  
10 communication unit can transmit a message;

11           determining if the percentage  $P_q$  for said neighbor is a maximum value from amongst  
12 the neighbors of the receiving communication unit;

13           calculating a difference  $d_q$  between a total number of neighbors of a communication  
14 unit having a maximum value of  $P_q$  and a total number of the receiving communication unit's  
15 neighbors  $N_k$ ;

16           wherein the receiving communication unit is determined not to be an articulation  
17 point if  $P_q$  of the receiving communication unit is greater than 85% and  $0 < d_q < 3$  and said node  
18 having a maximum value of  $P_q$  is one of a cluster-head and gateway communication unit.

1           6.     The method of claim 1, wherein said determining whether to retransmit  
2 includes using a predetermined algorithm to determine if one or more communication units  
3 identified within the network topology information are configured to broadcast a message to  
4 each of the receiving communication unit's first tier neighbors and no communication unit  
5 identified within the network topology information is configured to broadcast a message to a  
6 set of communication units that includes each of the receiving communication unit's first tier  
7 neighbors and at least one other communication unit that is not a neighbor of the receiving  
8 communication unit.

1           7.     The method of claim 6, wherein a plurality of communication units are each  
2 connected to one or more communication links, and the predetermined algorithm determines  
3 whether the receiving communication unit is connected to a greatest number of links with a  
4 quality exceeding a threshold from among said one or more communication units configured  
5 to broadcast a message to each of the receiving communication unit's first tier neighbors.

1           8.     The method of claim 6, wherein the predetermined algorithm determines if the  
2 receiving communication unit has a fewest number of hops to a gateway unit from among  
3 said one or more communication units configured to broadcast a message to each of the  
4 receiving communication units first tier neighbors.

1           9.     The method of claim 6, wherein each of the plurality of communication units  
2 has a unique identifier and the predetermined algorithm determines to retransmit the message  
3 based upon communication unit unique identifiers.

1           10.    The method of claim 9, wherein the predetermined algorithm determines to  
2 retransmit the message if the receiving communication unit has a smallest unique unit  
3 identifier among the communication units configured to broadcast a message to each of the  
4 receiving communication unit's first tier neighbors.

1           11.    The method of claim 9, wherein the predetermined algorithm determines to  
2 retransmit the message if the receiving communication unit has a largest unique unit  
3 identifier among the communication units configured to broadcast a message to each of the  
4 receiving communication unit's first tier neighbors.

1           12.    The method of claim 1, wherein a group of communication units among the  
2 plurality of communication units is assigned a first island identifier and the receiving  
3 communication unit is assigned a second island identifier, wherein the receiving  
4 communication unit transmits the message to the group of communication units if the first  
5 and second island identifiers are equivalent.

1 13. A method of transmitting a message to a destination communication unit  
2 within a wireless communication network having a plurality of communication units  
3 including an upper layer communication unit having stored therein routing information for  
4 routing to the plurality of communication units in the network, and a receiving  
5 communication unit having stored therein network topology information including identifiers  
6 of neighboring communication units from which the receiving communication unit has  
7 received a message forming a first tier of neighbors, and identifiers of communication units  
8 from which the first tier neighbor communication units have received messages forming a  
9 second tier of neighbors, the method comprising:

10 receiving at the receiving communication unit a message destined for a destination  
11 communication unit;

12 determining whether a direct path to the destination communication unit can be  
13 identified based on the network topology information stored within the receiving  
14 communication unit;

15 transmitting the message from the receiving communication unit to a next hop  
16 communication unit according to the identified path to the destination communication unit if  
17 said path is identified, transmitting to an upper layer communication unit if said path can not  
18 be identified, and transmitting via message flooding if the receiving communication unit is  
19 not associated with an upper layer communication unit.

1 14. The method of claim 13, wherein the message is transmitted using controlled  
2 flood techniques if no path to said destination communication unit is identified and the  
3 receiving communication unit is not associated with an upper layer communication unit.

1 15. The method of claim 13, wherein in determining a path to the destination  
2 communication unit, the destination communication unit must be located within a  
3 predetermined number of hops from the receiving communication unit.

1 16. The method of claim 14, wherein the predetermined number of hops is two.

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1 17. The method of claim 13, wherein the message received by the receiving  
2 communication unit is received from a traffic source unit internal to the receiving  
3 communication unit.

1 18. The method of claim 13, wherein determining a path to the destination  
2 communication unit further includes:  
3 searching a routing table, stored within the receiving communication unit, containing  
4 routes to destination communication units.

1 19. The method of claim 13, wherein determining a path to the destination  
2 communication unit further includes:  
3 searching a link cache, stored within the receiving communication unit, containing  
4 routes to destination communication units.

1 20. The method of claim 13, wherein if a direct path is determined based upon  
2 network topology information, the cost of routing the message via the direct path is compared  
3 with the cost of routing the message through a gateway node, and the next hop  
4 communication unit is selected based upon the result of said comparing of routing costs.

1 21. The method of claim 13, wherein the upper layer communication unit is a  
2 cluster-head communication unit.

1 22. The method of claim 13, wherein the upper layer communication unit is a  
2 gateway communication unit.

1 23. The method of claim 13, wherein receiving communication unit includes an  
2 island identifier, and the receiving communication unit detects an island identifier in the  
3 message and processes that message only if the island identifier of the message matches the  
4 island identifier of the receiving communication unit.

1 24. The method of claim 13, wherein if the size of the message exceeds a  
2 predetermined threshold the receiving communication unit outputs a probe request using a

3 flooded message broadcast to detect a route to the destination node, and the receiving  
4 communication unit transmits the message based on the route detected using the probe  
5 request.

1 25. The method of claim 13, wherein if the size of the message exceeds a  
2 predetermined threshold the receiving communication unit outputs a probe request using a  
3 controlled flood broadcast to detect a route to the destination node, and the receiving  
4 communication unit transmits the message based on the route detected using the probe  
5 request.

1 26. The method of claim 13, wherein the message is transmitted using a flooded  
2 message broadcast if the transmission to said next hop communication unit fails.

1 27. The method of claim 13, wherein the message is transmitted using a controlled  
2 flood broadcast of the message if the transmission to said next hop communication unit fails.

1 28. The method of claim 13, wherein the message is transmitted using a flooded  
2 message broadcast if said next hop communication unit is determined to no longer be a  
3 neighbor of the receiving communication unit.

1 29. The method of claim 13, wherein the message is transmitted using a controlled  
2 flood broadcast message if said next hop communication unit is determined to no longer be a  
3 neighbor of the receiving communication unit.

1 30. A method of selecting a top level routing unit in a network of communication  
2 units, the communication units organized in a plurality of clusters each cluster having a  
3 cluster head with network topology information including information concerning  
4 neighboring communication units within the cluster, the method comprising:

5 a) determining, at a first cluster head, a second cluster head among cluster heads  
6 identified in the first cluster head's network topology information, having a largest number of  
7 neighbors among the cluster heads identified in the first cluster head's network topology  
8 information; and

9           b) selecting the second cluster head as the top level routing unit.

1           31.    The method of claim 30, wherein the cluster heads have identifiers and if two  
2   or more cluster heads identified in the first cluster head's network topology information have  
3   the largest number of neighbors, selecting the cluster head among said two or more cluster  
4   heads based on the cluster head identifiers.

1           32.    The method of claim 30, wherein the top level routing unit is a gateway  
2   communication unit having a tree with routing information for routing a message to the  
3   communication units within the network.

1           33.    The method of claim 30, further comprising c) repeating a) and b) after a  
2   predetermined amount of time.

1           34.    The method of claim 30, further comprising c) repeating a) and b) after the  
2   first cluster head receives a predetermined number of beacon messages from communication  
3   units that are members of the first cluster head's cluster.

1           35.    A method of a communication unit joining a gateway unit in a communication  
2   network having a plurality of clusters of communication units, each cluster having a cluster  
3   head, wherein a first communication unit is a neighbor of a second communication unit if the  
4   first communication unit is within broadcast range of the second communication unit, the  
5   method comprising:

6           sending a gateway join message to the gateway unit if a joining communication unit  
7   sending the message is a neighbor of the gateway unit; and

8           sending a gateway join message to the gateway unit if the joining communication unit  
9   is not a neighbor of the gateway unit, and if neighbors of a joining communication unit  
10   sending the join request are affiliated with a cluster head and a cluster head that is a neighbor  
11   to the joining communication unit has a path to the gateway unit.

1           36.    The method of claim 35, wherein the join request includes information  
2   identifying communication units within the cluster of the joining cluster head.

1 37. The method of claim 35, wherein the join request includes information  
2 identifying multicast groups of which the communication units of the cluster of the joining  
3 communication unit are members.

1 38. The method of claim 35, further comprising:  
2 receiving a join acknowledgement message acknowledging receipt of the join request,  
3 wherein the join acknowledgement message enables the receiving communication unit to  
4 determine its upstream, downstream and next hop to reach the destination of the JOIN-ACK.

1 39. A communication unit suitable for use in a communication network of a  
2 plurality of communication units, the communication unit comprising:

3 a network topology storage unit having stored therein network topology information  
4 including identifiers of neighboring communication units forming a first tier of neighbors and  
5 neighbor sets identifying neighbors of the first tier neighbors forming a second tier of  
6 neighbors; and

7 a message forwarding unit configured to forward a multicast message using a  
8 controlled flood broadcast technique and to forward a unicast message to a destination  
9 communication unit using a unicast technique if the network topology information stored in  
10 the storage unit includes information identifying a next hop in a route between the  
11 communication unit and the destination unit and using a controlled flood technique if the said  
12 network topology information does not include information identifying said next hop.

1 40. The communication unit of claim 39, further comprising a dynamic network  
2 maintenance module configured to revise the network topology information stored in the  
3 storage unit in response to receiving beacon information from a neighboring communication  
4 unit.

1 41. The communication unit of claim 40, wherein the dynamic network  
2 maintenance module periodically selects a gateway for routing messages based on the  
3 network topology information in the storage unit.



1           42.     The communication unit of claim 41, wherein the communication unit is a  
2     radio and the communication network is an ad-hoc network of radios.